ON-LINE REAL-TIME INFORMATION SYSTEM

IN MANUFACTURING - KEY TO SURVIVE?

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ABSTRACT

The electronics manufacturing industry in Hong Kong must face two fundamental challenges in the 1990s: high labor costs and tough foreign competition. Therefore, innovation in the manufacturing process is important for the industry to become more competitive in the future.

This research report proposes an economic On-Line Real-Time Information System for small to medium sized electronics manufacturing firms. This On-Line Real-Time Information System is believed to be able to increase the productivity and competitive strengths of the electronics manufacturing industry in Hong Kong and to maintain its vitality in the future.

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CHAPTER I

INTRODUCTION

The electronics industry has been maintaining its position as the second largest manufacturing industry in Hong Kong for years. According to government statistics, domestic exports of electronic products in 1988 were valued at $55,561 million, which was about 26 percent of the overall domestic exports value.

However, the industry has been suffering from the inefficiency of the manufacturing process, especially in the labor-intensive production function. This can again be illustrated by the 1988 government statistics. Although the industry accounts for 30 percent of labor force, it contributes only 26 percent to gross domestic product. The problem becomes more critical as indicated by the increase in shortage of the labor supply and the high labor cost recently found in Hong Kong. Therefore, the efficiency of the manufacturing process has to be increased in order to maintain Hong Kong's competitive edge in the electronics industry.

One of the most important activities of manufacturing is the production function. It is especially true in Hong Kong since most electronics manufacturing firms are dealing with Original Equipment Manufacturers (OEM) products where Research and Development (R&D) and other related activities are of lesser concern. A lot of studies have been made in the area of Production Planning and Scheduling for manufacturing industries. Different techniques for Master Production Scheduling (MPS) and Materials Requirements Planning (MRP) have been introduced.[1] Gantt Charting and the Program Evaluation and Review Technique (PERT) are also developed for this purpose.[2] While they are good for the production planning, the application of these techniques will have little benefit on monitoring and controlling the dynamic production environment of the industry. However, it is the lack of these monitoring and controlling activities that results in the inefficiency of the manufacturing process of the industry in Hong Kong.

The major reason for this is that the companies in the manufacturing sector in Hongkong have been slow in using computers. According to a survey undertaken by the Hong Kong Federation of Industry and Graham Mead Associates, only one in ten manufacturers in the industry use computers[3] and they are used mainly for accounting functions only. Computerisation has not reached the factory floor for the monitoring and controlling purpose of the manufacturing process. However, these production control activities have a great potential for computerisation.

This research report suggests an effective and cost-justifying way to improve the efficiency of the manufacturing sector in the electronics industry in

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1. Everett E. Adam, Jr. and Ronald J. Ebert. "Production and Operations Management: Concepts, Models and Behavior", 3 ed., Prentice-Hall International, 1986, pp. 360.

2. Ibid.

3. Tan Lee Hock, "Computers in Manufacturing", Asia Computer Weekly Publication, Nov 14 1988. pp. 52

Hong Kong: the application of On-line Real-Time Information Systems. Special attention is paid to production control. The study is based on the results of an survey done on some electronics manufacturing firms in Hong Kong. Through an analysis of the results, a tentative picture can be built up of the current status and pattern about the availability, usage and satisfaction of computers for production control purposes.

In addition, a study of the applicability of the suggested system in a medium sized electronics manufacturing firm in Hong Kong is presented. This study attempts to provide a more complete picture of the production environment in Hong Kong and anticipates possible benefits as well as difficulties that may happen when the suggested system is implemented.

The study will concentrate on electronics industry only because people working in the industry are believed to have stronger computer knowledge background. Thus it is easier to obtain the commitment of different department managers in implementing the suggested information system. On the other hand, people in other traditional manufacturing industries tend to be more resistant to new idea and technology. However, it is argued that the idea of computerisation in manufacturing will eventually have important impact on all manufacturing industries.

Research Methodology

The focus of the research is on the technical as well as organizational issues associated with the application of the On-line Real-time Information System in the electronics manufacturing industry in Hong Kong. Information concerning the extent of factory-floor computerization were derived mainly through the results of a primary exploratory survey. Questionnaires concerning the status of factory-floor computerization were sent to 100 electronics manufacturing firms in Hong Kong, ranging from small to medium sized (less than 1,000 employees), in December, 1989. A total of 32 valid responses (32 percent) were obtained. The response is considered encouraging.

Information on the advancement in factory-floor computerization of companies in other countries is obtained through extensive library research. The information is used as a guideline of what electronics manufacturing firms in Hong Kong may follow.

CHAPTER II

FACTORY-FLOOR COMPUTERIZATION OF ELECTRONICS MANUFACTURING INDUSTRY IN HONG KONG.

This chapter focuses on the extent of factory-floor computerization of the electronics manufacturing industry in Hong Kong as compared with other countries. The study is mainly based on the results of the survey conducted in December, 1989 and information collected from literature review.

An Overview of the Worldwide Electronics Manufacturing Industries

Electronics manufacturing generally refers to the entire product design and production cycle including product design, production planning, manufacturing, distribution, field service and reclamation.

The electronics industry of the world is now facing the following environmental and marketing condition:

- competition among enterprises is fierce
- product life is short
- technological evolution is rapid
- customer's needs are diversified

In order to survive and remain competitive in this dynamic industry, the production control functions in the electronics industry must achieve the followings:

- quick adaptation of newly evolving technologies
- flexibility enhancement towards frequently occurring technical changes, production engineering changes
- continuous cost reduction
- lead time minimization
- more multiple-products and smaller-quantity production

Aiming at high-productivity, high-flexibility production, top-down approaches are vigorously taken in the electronics industry in technology advanced countries like Japan, U.S. and Western Europe. The top-down approach involves, firstly, the introduction of automated hardware, such as NC (Numeric Control) machines, robotics, FMS (Flexible Manufacturing Systems), CIM (Computer Integrated Manufacturing), etc, and secondly, the computerization of production planning and control and the EDP (Electronic Data Processing) of shop floor data collection.

A survey was done in 1987 to investigate the implementation of minicomputer-based manufacturing planning and control systems in Sweden[4]. The summary of the results were as follows:

- implementation of minicomputer-based manufacturing planning and control systems was basically a strategic decision.
- the higher production complexity, the more extensive the use of the computer-based manufacturing production and control system.
- more than 90 percent Swedish manufacturing companies had implemented minicomputer-based manufacturing planning and control systems by 1980.
- the company size seems to be a significant factor in the overall use of manufacturing planning and control system modules. In large companies, the information system is often more structured, formal and diverse, which facilitates computerization.
- the sophistication of computer based manufacturing planning and control has increased during period from 1980 to 1987. Major increase was in the use of individual modules including shop floor control (up 63 percent), capacity planning (up 57 percent), cost control (up 55 percent), aggregate production planning (up 34 percent) and simulation (up 30 percent).

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4. Matsson, Olhager, Ovrin and Rapp "Computerization of Manufacturing Planning and Control System: Minicomputer-based Systems 1980-1987" in Engineering Costs and Production Economics, August 1989, pp. 71-78.

From the above examples, it can be deduced that computerization of factory-floor is the natural trend for electronics manufacturing firm to remain competitive in this dynamic electronics industry. The most controversial application of computers in the manufacturing industry is Computer Integrated Manufacturing (CIM) which will be briefly described in the next section.

Computer Integrated Manufacturing (CIM)

Computer Integrated Manufacturing (CIM) is a concept that combines various technologies to produce an entirely integrated factory. There are many definitions for a CIM system, but usually CIM consists of such technologies as computer aided design and computer aided manufacturing (CAD/CAM), robotics, automated material handling and identification, machine vision, and communications network that links them together.

In addition, the appropriate functional areas such as marketing, purchasing, accounting, and finance should be integrated with CIM components.

A list of the key elements of the CIM structure can help to delineate the concept:

- shared data base
- automatic data gathering
- networking
- material resource planning (MRP)
- management resource planning (MRP II)

- automated storage and retrieval systems (AS/RS)
- robotics
- computer aided design/computer aided manufacturing (CAD/CAM)
- numerical control machines (NC Machines)
- computer aided quality control (CAQC)
- artificial intelligence (AI)
- computer aided production planning (CAPP)

In summary, the key to successful production management is the integration of all the elements of product manufacturing, namely, product design, production, distribution, etc. into a complete system.

Examples of Applications of CIM in Western Manufacturing Firms

CIM Centre Munich (IBM)

The CIM architecture of the IBM CIM centre in Munich is based on IBM's own hardware and application software, extended by special software systems from software houses. These systems are suited to the development, design and pricing of assembly parts, and to the simulation of robots and moving models.

CAI Concept (Siemens)

The Siemens Computer Aided Industry (CAI) concept consists of the functional areas of production planning and control (PPC), computer aided engineering (CAE), computer aided manufacturing (CAM) and ,included in the concept of computer aided office (CAO), comprehensive computerized functions of the personnel, finance and accounting departments along with enterprise planning and office communication.

DEC

Digital Equipment Corporation (DEC) constructed a CIM system which incorporates workstations for order handling, design, NC programming, production planning, job-shop control, manufacturing and operational data collection, which are connected together in a common CIM concept. Moreover, there is a workstation for inventory management planning based on an expert system. The hardware vase comprises various sizes of DEC computers along with machine controls from other manufacturers.

CIM Technology Canter (Nixdorf)

Nixdorf Computer AG opened the CIM technology centre in Stuttgart in February in 1987 which underlined its commitment to the sector integrated computer solutions for manufacturing industry. The CIM system supports all the operational sequence of an industrial firm: from sales through development and design, process planning, materials management and NC programming to production planning, production and quality assurance. It is truly a paper-free system with current production information available locally at any time through any workstation.

Tandem Computers in Austin

An excellent example of a "paperless" factory is the Tandem Computers facility in Austin, Texas, that develops and manufactures terminals and work stations. Kits for work orders and on the tracking of individual work pieces are eliminated through the entire manufacturing process. The activities of work stations can be directed, monitored and controlled in an integrated manner and in real-time mode. Information concerning the level, location, and quantity of individual work pieces on the factory floor can be easily available in real time. Moreover, the material, labour and machine utilization throughout the entire production process can be visible in any computer terminals.

Electronics Manufacturing Industry in Hong Kong

The situation of the electronics manufacturing industry in Hong Kong is somewhat different from that of the Western manufacturing firms. Most electronics manufacturing firms in Hong Kong deal with OEM products only. They are not involved in the design process, product distribution and field service. Therefore the production process becomes the manufacturers' main interest.

The most important characteristic of the production process in electronics manufacturing industry that differentiates it from other industries is its complexity. There are close interrelationships among different departments of an electronics manufacturing firm. This multilayered interaction among different departments makes the production process very complicated and therefore mistakes made in a particular department may affect the whole production process.

To illustrate the complexity, a flow-chart of a particular production process is shown in Figure 1. In the first stage, samples of raw materials are

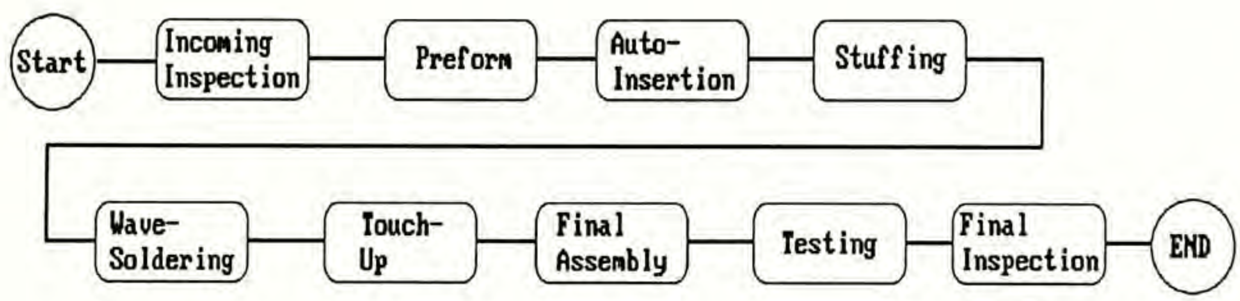

Fig. 1 The Production Process

inspected and electrically tested according to vendors' specification. After that, these raw materials will be passed to the preform stations for pre-stuffing preparation. Stuffing of materials onto printed-circuit boards (PCB) is usually done by hands or by auto-insertion machines, depending on the kind of components involved.

After all the components are stuffed, the PCBs are prepared for wave-soldering. After that, these PCBs are passed to the Touch-Up stations for inspection and poor solder joints will be reworked at this stage. Additional components which cannot be stuffed before wave-soldering will be added in the Final Assembly stations. These PCBs will then be prepared for functional tests in the Testing Department. Finally, all the PCBs that pass the functional tests will be visually inspected again before shipping to customers.

Large amounts of data will be generated and collected within the whole process by each department. However, the data is useless unless it is turned into meaningful information for management. There are at least five categories of information that the management is most concerned about: the level of the raw material, the level of work-in-process inventories, the yield rate of each department, the stocks of finished products and the information of the changing of products.

What is more, the product life cycle of most electronic products is usually very short. As a result, changes of the production process have to be made frequently, and thus further complicating the process.

Therefore, reliable and efficient Information System for monitoring and controlling of the production process is extremely important for the industry.

Production Control Problems in Electronics Manufacturing Firms in Hong Kong

In most electronics manufacturing firms in Hong Kong, as indicated in the results of the survey, production control is done manually by a large number of dedicated persons, usually the controlling clerks and supervisors in each department. They are responsible for preparing progress and status reports of the factory-floor data for management. An example of the structure of the system is illustrated in Figure 2.

The major drawback of this control mechanism is that, even assuming that it is economically feasible to employ such large number of people, it will be difficult to prepare all the up-to-date and accurate reports required for management's attention and actions. For example, it might take some time for

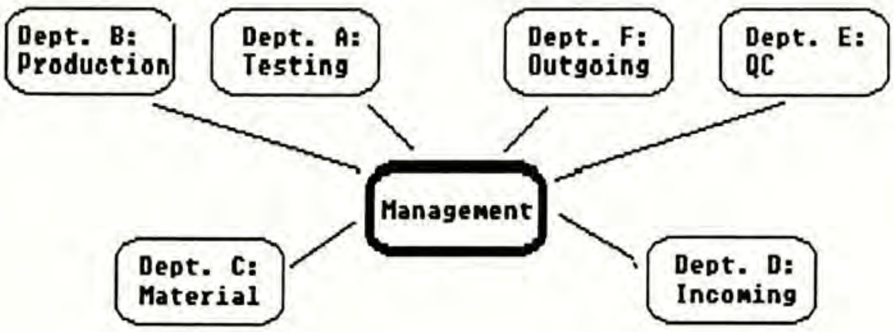

Fig. 2 Structure of Conventional Manual System.

each of the different departments to prepare the data. The responsible clerks will then take another while to gather these large amounts of data. It is not unusual that the clerks will spend days in converting these raw data to useful information as well as reports for management use. Therefore, with a manual system, it is very hard to obtain timely information of the factory-floor. As a result, the productivity of the production process will be decreased.

Another problem frequently encountered by this conventional manual control system is the lack of communication among different departments. The reason is that managers of different department do not always see each other. The way they communicate with each other is mainly through a vast amount of paperwork, such as forms, orders, document, circulating among different departments. Again, the paperwork delay can cause decrease in the productivity of production process.

It is suggested that a better Information System, which is able to distribute the factory-floor information to management in a real-time manner, is essential for the electronics manufacturing firm to face the dynamic production environment in Hong Kong. With the recent decline in prices and increase in performance of micro-computers like the 80286 and 80386 machines, it is possible to install the information system with relatively low costs.

The Survey

In order to understand more about the computerization in the factory-floor level of the electronics manufacturing industry of Hong Kong, a survey was conducted in January of 1990 to collect the required information.

Objectives

In order to design the proposed On-Line Real-Time Information System, a real picture of computer applications for production controls in electronics manufacturing firms in Hong Kong must be established first. As there is no secondary sources of information on this subject, a primary research is needed to collect the require information. The objectives of the research include:

- to investigate the extent of computerisation for production control
- to understand how production control functions are carried out now and how computers can be used for production control purposes
- to investigate the current information systems used by electronics manufacturing firms for production control purposes
- to collect information on the efficiency of the current production control systems

Survey Design

The survey was basically an exploratory research to gain insights into the current production control information systems adopted by electronics manufacturing firms in Hong Kong. The survey conducted was a descriptive cross-sectional survey. The detail design of the survey was as follows:

Communications Method

Under the time and cost constraints, the questionnaire approach was the best communication method. The form of questioning used was basically structured, undisguised with fixed-alternative questions. This could facilitate tabulation, which was a major part of the analysis, through standardization of responses to ease coding efforts.

Method of Administrations

The method of administration must be inexpensive, yet effective in obtaining representative data. Telephone interviews, although inexpensive, was not suitable to collect complex information which required much thinking and analysis. Finally, mail questionnaire was selected because it was easy to conduct even though it usually offered low response rate and long response time.

Questionnaire Design

A questionnaire was prepared (please refer to Appendix 1) and the detail design of each question was shown in Table 1.

TABLE 1

DESIGN OF QUESTIONS FOR THE SURVEY

Question No.	Description
1	To screen out non-target respondents
2	To get the company size and relate it to the extent of computer applications for production control
3	To check whether computers are used and to identify the reasons if computers are not implemented
4	To check the history of using computer and relate it to the application on production control
5	To examine the extent of investments in computer hardware and the scale of computer hardware used for production control
6	To investigate how computers are used and emphasis is put on production control
7,8,9	To investigate the different components of the production control information systems currently used by electronics manufacturing firms
10	To check whether inefficient production control system can reduce production capacity and to identify the possible causes
11,12	To estimate the losses due to inefficient production control systems
13	To check the opinions of managers on the use of On-Line Real-Time Information System for production control

Sample Design

The target population was the small and medium sized electronics manufacturing firms. As questionnaires were mailed to electronics manufacturing firms randomly selected from the Directory of Hong Kong Electronics Manufacturers, this was basically a probability sample.

In order to figure out the sampling size, the degree of confidence and precision required must be defined first. Since most of the results are related to proportions, the proportion sampling size formula is used:

$$n = Z^2(P)(1 - P)/e^2$$

where n - sample size

P - population proportion

e - standard error

Z - number of standard deviations for the confidence interval chosen

For 90 percent confidence interval and standard error of 15 percent with the worst estimation of population proportion of 0.5, the sample size calculated from the above formula is 30. Assuming the response rate is 30 percent, 100 questionnaires have to be prepared.

Survey Results

There were totally 39 responses to the questionnaires. Since three questionnaires were returned because of wrong mailing addresses, the response rate was 36 percent which was in expectations. Of the 36 valid responses, four of them were non-manufacturing firms, so the analysis only based on the remained 32 questionnaires.

One Way Tabulation Analysis

The one way tabulation of the survey results is shown in Appendix 2. From the simple frequency analysis of the survey data, the following conclusions can be reached:

- as 80 percent of the surveyed firms have number of employees less than 1,000, the survey results can represent the use of computer for production control in small and medium sized firms.
- all the electronics manufacturing firms are currently using computer for data processing which indicates that computers are commonly used by Hong Kong electronics manufacturing firms. However, the PC to staff ratio is only 1:12.4 indicating that the extent of using computers is rather low.
- the Hong Kong electronics manufacturing firms generally have good experience in using computer as half of the surveyed firms indicated that they have been using computer for more than four years.
- the most popular type of computer used by the electronics manufacturing firms is micro-computer (95 percent) which is followed by mini-computer

(45 percent). Mainframe is not used by any of the surveyed firms. The average number of micro-computers installed is 33.74 with a standard deviation of 38.95 which means that the variation in number is very high with as little as one to more than one hundred.

- computers are used for all the types of applications suggested, namely, word processing, accounting, production planning, production control, manufacturing database, sales analysis, forecasting and CAD/CAM. The most popular applications are word processing and accounting (85 and 80 percent respectively). Only about half of the surveyed firms indicated that they are using computers for production control and planning. For the production control functions, the most popular applications are material requirement planning (100 percent) followed by master scheduling (85.71 percent) and vendor scheduling (57.14 percent). For the production planning functions, the most popular applications are inventory control (100 percent) followed by cost control (70 percent).
- for the production planning and control information system, the factory-floor data is usually collected by clerks (70 percent), and reports are submitted to the management from each department independently without consolidation. Ten percent of the surveyed firms even indicated that no formal report is produced. Production data is usually (75 percent) collected and entered manually by clerks into computers for processing. None of the surveyed firms use electronic devices to automatically collect production data. Most of the production status

reports are produced on a weekly basis (40 percent) while some surveyed firms (45 percent) indicate that their production reports are produced daily. In another word, eight-five percent of the surveyed firms generate their production reports with frequency higher than or equal to once per week.

- more than half (65 percent) of the surveyed firms indicated that their production capability is reduced due to the inefficiency of the production control system. The major reasons for inefficiency are material shortage and slow response to material defects.
- the average estimated losses due to the inefficiency of production control system is 10.65 percent of the manufacturing cost.
- more than half (75 percent) of the surveyed firms believe that a On-Line Real-Time Information Systems for production control will be beneficial to their firms.

Cross Tabulation Analysis

By cross tabulating the responses of different questions and examining the cross tabulation tables, the following conclusions can be reached:

- the larger the size of the firm is (in terms of number of employee), the greater is the number of micro-computers installed. When a firm increases in size, computers are commonly used to reduce the cost of operations by improving the production efficiency

No. of Employee	No PC	With PC
< 200	40%	47%
> 200	60%	53%

- the larger the size of the firm is, the higher the frequency of production status report is required. When a firm gets larger, the production volume will also increase. Even short production stoppages can lead to great production loss. Therefore, timely information is needed to closely monitor the production processes

No. of Employee	More than Once/Wk	Once/Wk
< 200	30%	60%
> 200	70%	40%

- the timeliness of production status report generation is positively related to the efficiency of the production control system. The higher the frequency of production status report is produced, the higher the efficiency of the production control system will be. To improve the efficiency of the production control system, a On-line Real-Time Information System for production control is needed

Freq.	Without Problems	With Problems
Once/Day	71%	46%
Once/Week	29%	54%

- the larger the size of the firm is, the stronger the need for a On-Line Real-Time Information System. When a firm gets larger, its production processes will become more complex. A On-Line Real-Time Information System is required to maintain the efficiency of production

No. of Employee	On-Line Not Useful	On-Line Useful
< 200	75%	33%
> 200	25%	67%

- many managers believe that a On-Line Real-Time Information System can help them to solve the problem of production control inefficiency.

Results of the Analysis

Computers are now widely used in electronics manufacturing firms, but the applications are mostly limited to word processing and accounting, and less than half of the respondents indicated that they use computers for production planning and control. The most popular computers are micro-computers (or PC). Moreover, production data is usually collected and manually entered into computers for analysis by clerks, and so the response lead time is long and the production capacity is reduced.

When an electronics manufacturing firm grows in size, production problems will occur more frequently due to the increase in the complexity and volume of the production processes. In order to solve the inefficiency problems, many managers believe that a On-Line Real-Time Information System can be the solution.

The Solution: On-Line Real-Time Information System

In order to solve the problem of production inefficiency of the small to medium sized electronics manufacturing firms in Hong Kong, one possible solution is to employ the CIM concept which is believed to be the trend of the development of factory production by the developed countries.

In Hong Kong, there are a few production firms which are now installing CIM systems e.g. Chen Hsong Machinery Co. Ltd. and Motorola Semiconductors H.K. Ltd. For example, Chen Hsong Machinery Co. Ltd. installed the first CIM system in Hong Kong in 1988[5]. The CIM system is comprised of eight HP 9000[6] series 319C engineering workstations networked by HP Thin-LAN to share centralized data storage and output devices. The workstations are linked to numeric control (NC) machines to automate the complete design and production processes. Computer-aided-design and computer-aided-manufacturing (CAD/CAM) packages including HP Mechanical Engineering Series 10 & 30 and D.P. technology ESPRIT are also installed. This production control system is linked with Chen Hsong's business system to provide a complete CIM solution. The total contract value just for the

5. Electronics Bulletin, Vol. 8, No. 4, pp. 60-61

6. Hewlett-Packard, a large American computer and electronic instrument manufacturing firm.

computerized production control system excluding all the NC machines amounted to US$1 million.

However, from the survey, the average monthly production volume of the small to medium sized electronics manufacturing firms in terms of U.S. dollar is only 2.5 million. Therefore, it is doubtful whether these firms can afford or justify such large capital investment to improve their production capacities.

From the survey, the following characteristics of the small to medium sized electronics manufacturing firms can be identified:

- all the firms are now using computers (mostly PC) for data processing
- most of the firms have good experience in using computers
- most of the firms agreed that real time production data can help them to improve their production capacities

Based on the special features of the Hong Kong small to medium sized electronics manufacturing firms, an On-line Real-time Information System is suggested to solve their productivity problems. This suggested On-Line Real-Time Information System is not a complete CIM systems like those implemented in large manufacturing firms. Instead, it is an important element of a CIM system. However, this On-Line Real-Time Information System can provide the necessary basic functions to improve the production capacity of the small to medium sized manufacturing firms without incurring excessive capital investments.

The suggested On-Line Real-Time Information System should be able to achieve:

1. Providing Real Time Information

The system should be able to collect, process and distribute factory-floor real-time production information to all department managers and present the information in easy understanding format.

A real-time system is defined as a system in which the transactions data are captured at source followed by immediate updating of the affected records, thereby making it possible to control the environment in which the system is operating.

2. Resource Sharing

The System should facilitate management to access all the data that is shared by different departments.

3. Security

The information required for production control, including the current status and the historical data, is considered the companies' asset. Therefore security is important in order to prevent unauthorized retrieval and alternation of information stored in the system.

4. Ease of Future Expansion

The System should allow easy expansion to cope with the future needs of the company. In addition, the performance of the System should not be degraded by the expansion.

5. Simplicity in Installation

The implementation of the system should be simple and the installation can be done by existing computer personnel.

6. Acceptance by Management and Regular Users

In order to gain management commitment of the System and the acceptance by all the department managers, the system must be simple and easy to use and retrieve information.

7. Cost Efficient

The cost of the System must be economic, including the initial set-up cost and the incremental cost for further expansion.

A wide range of benefits can be expected from a proper implementation of the suggested On-Line Real-Time Information System. Some of these are:

- access to real-time information from the factory-floor
- monitoring of the production process with minimal number of supervisors required
- promptly alarm of department managers if something goes wrong
- instant alarm and display of the fault
- faster response to change i.e. ECO
- reduced WIP inventories & lead times required

There are two main factors that reinforce the feasibility of the suggested On-Line Real-time Information System. The first factor concerns the technological advances in the area of high-speed microprocessor that make real-time operation possible.

The second, and most important factor, is that most small to medium sized manufacturing firms have already had the hardware requirement of the suggested Information System: micro-computers. All the manufacturing firms have to do is to utilize the existing facilities by integrating the individual machine into a complete Information System. As a result, the value of existing investments is protected and the cost for setting up the system is greatly reduced, as compared with the installation of completely new systems.

With the implementation of the On-Line Real-Time Information System, the productivity loss caused by the lack of up-to-date production information such as material shortages, defect overlook, excess inventory can be greatly reduced.

CHAPTER III

A STUDY OF THE APPLICABILITY OF THE SUGGESTED ON-LINE REAL-TIME INFORMATION SYSTEM TO A MEDIUM SIZED ELECTRONICS MANUFACTURING FIRM IN HONG KONG.

In this part of the research report, the applicability of the suggested On-Line Real-Time Information System to a medium sized electronics manufacturing firm in Hong Kong will be studied. Due to the confidential information involved, the company will be anonymous and named as XYZ thereafter.

The Company

XYZ, a American-based contract manufacturing firm, specializes in manufacturing computer-based board assemblies. The president believes that the next step for XYZ to grow will be to capture large turn-key contracts from nation-wide customer. The aggressive efforts in marketing has acquired the company several order commitments but at a lower manufacturing price than it is possible at present.

Thus, to capture these new business, the cost of manufacturing will have to be cut by about 30 percent. Estimating future volume at HK$200 million, the president of the company has ordered new manufacturing technologies to yield half of the targeted cost reduction. The other half of cost reduction would be accomplished by employing better production controlling system to improve the efficiency of the manufacturing process.

A Study of the Existing Production Controlling System

An NCR mini-computer had been installed in the factory for more than a year. It is primarily used for preparing Material requirements planning (MRP) up to the raw material receiving level. Due to the hardware and software limitation of the NCR computer, production control cannot be implemented with the existing facilities. Instead, IBM PC compatible micro-computers are used for this purpose.

There are totally about 20 PC compatible micro-computers used by the departments. The PC to staff ratio is about 1:6. Approximately half of the computer time is allocated for general production purpose like historical data entry, schedules preparation and work travellers generation. The other half is allocated for data backup, file transfer and printing or just simply idling. Although large amount of data is entered into the computer from each department, there is no standard storage format of the data. It is all up to the department managers to decide what kind of data and in what format these data are stored. Data may even have to be printed out in one department and manually re-entered into other computers in order to share with other departments.

Moreover, these micro-computers are not used for generating the information required for management. Instead, this is done by a team of workers who walk through the plant with clipboards and collect large amount of data from each department in a form of paperwork. After that, the data is manually re-entered into computers to be converted to meaningful information for management.

Collecting information in this manner has several drawbacks. Data accuracy is not guaranteed and data is hours, even days old before it is entered into computers for analysis. And the most serious problem is that this method does not allow managers in different departments to directly interact with the plant to correct problems as soon as they arise. In other words, the existing manual capabilities cannot cope with the required measurement speeds, analysis speeds and reliability. Therefore, in order to achieve the 15 percent cut in the production costs that is required by the president, a new information system is required for the purpose of production control.

Problems with the Existing Production Control System

The existing production control system of the company experiences a lot of problems and deficiencies common to most electronics manufacturing firms in Hong Kong. These problems can lead to the unnecessary loss of production capacity. Some of these problems are:

Delay in Distributing Up-dated Information on Materials Inventories

A reliable means of tracking materials inventories is fundamental to the effectiveness of the whole production process. Since most of the materials arrive at irregular rates, sudden shortage of say a particular component always happen. It might result in idling of some production lines and when this component is re-stocked, these production lines may be severely overloaded.

To minimize the repercussions of the shortage of materials, the department managers should reallocate the resources from this particular product to other products in order to prevent any wastage of labor, facilities and equipment. However, this can only be done if the managers can be notified right after the shortage problem is found. Unfortunately, with the current production controlling system, the information will not reach the managers without hours or even days of delay. As a result, prompt reaction cannot be carried out by the managers and thus causing loss in productivity.

Problems in Tracking Work-in-process (WIP) Inventories

The amount of work-in-process inventories is very important to reflect the efficiency of the production process. If exceptionally high WIP inventories are found within the process, it might indicate that work loads are not evenly distributed across the various production lines. High work-in-process inventories means high production cost. Therefore timely, useful and accurate data on the amount of the WIP inventories is very important for the management to keep the inventory level within defined limits. However, the current information system is far from providing these information for the management.

Problems in Monitoring the Yield Rate of Different Departments

The yield rate of the outputs of each section in the production process should be within the defined tolerance limits.

There are a lot of reasons that cause an abnormal low yield rate. It may simply be caused by false rejects of defective machines or by unskilled operators who are not well-trained enough. On the other hand, it can be caused by more serious problems like poor quality materials or mistakes happened in some stations in previous production process. Therefore, in order for the management to take prompt actions before the whole process gets out of control, it is very important for the management to collect accurate and up-dated yield rates in a real-time manner.

Problems with Unexpected Machine Down Time

As mentioned before, defective machines may cause severe loss in productivity. Under the current manual system, if there is a sudden machine breakdown, it is possible that the management is not notified until the end of the day. All the succeeding activities that depend on this particular machine are unnecessarily delayed.

In addition, under the existing system, machines utilization and efficiency reports are generated once a week only. The management does not have the up-dated information on machines utilization, thus affecting their future planning.

Slow in Response to the Change of Products

As mentioned before, unlike other products, electronic products are constantly being changed and up-dated. These changes would affect part or all of the production process. Adjustment of various departments is thus required to meet the changes.

The adjustment may need a long set-up time depending on the extent of these changes. The earlier the department managers are notified, the more the time they have to prepare the production process for the changes in order to minimize the effects caused by these changes. However, with the current system, there is often a delay before these information can reach the managers involved. What is more, the accuracy of the information is not guaranteed. As a result, the production cost will be increased.

Loss of Productivity in Paperwork

In the current manual information system, workers have to spend on average ten percent of their time doing paperwork like recording the flow rate of products, filling in the "travellers" that are attached to the products, calculating the yield rate of the machines and so on. This represents a ten percent loss in productivity[7].

Reliability of Information

The accuracy of the data collected under the existing manual system is not guaranteed and is subjected badly to human errors. These errors can occur when workers collecting the data or when these data are being keyed into the computers.

To conclude, the need for improved efficiency and flexibility in the flow of information, across all the production activities, is now well recognized. This need has stimulated the development of an on-line and real-time approach for production control.

OLRTIS

OLRTIS (On-Line Real-time Information System) is an information system that aids the management in the control of the production process. The system can be viewed as two modes. As a Data Collection System, it will facilitate the data collection process of factory-floor information with accuracy guaranteed. As a Data Retrieval System, it can provide most up-dated and reliable

7. The inefficiency rate is obtained by a time-study done by the company in December, 1989

information that is useful for the management in monitoring the production process and keeping it under control. Thus information can flow where it is needed when it is needed.

The most important capabilities of the OLRTIS are identified as follows:

- to distribute reliable factory-floor information to all department managers in real-time and continuous manner
- to present the information in easy-to-understand graphical format
- to provide real-time visibility and historical trend for gaining insight into the nature of machine downtime, utilization and other production conditions
- to monitor and control the work-in-process (WIP) inventory

The principal objective of these applications is thus to reduce the possible loss in production cost due to the inefficiency of the existing production control system.

The Design of OLRTIS

The proposed structure of the OLRTIS for the company is shown in Figure 3.

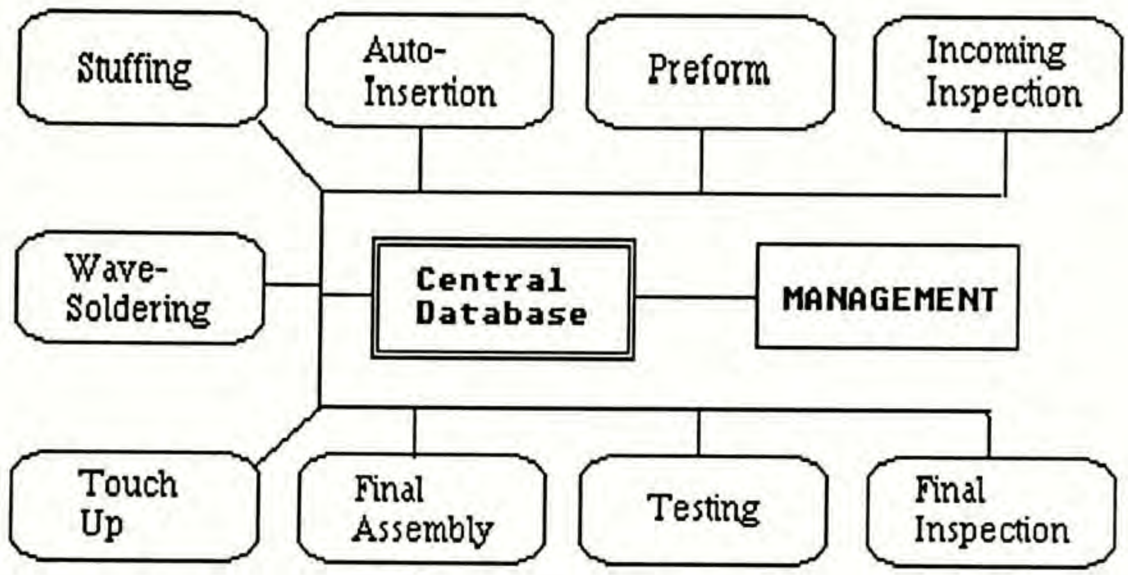

Fig.3 The Structure Diagram of the OLRTIS

The new structure has significant improvement as compared to the one shown in Fig. 2. Other than allowing management to gain access to the production information in each department efficiently, the new structure also ensures that all the departments can "talk" to each other directly, thus allowing actions to be taken promptly by the management when problems arise in a particular department.

The rest of this section will discuss the requirements of the new system, including the hardware and software requirements and the additional human resources that is needed for the new system.

The Hardware

One of the features of this proposed OLRTIS is that it requires minimal hardware set-up cost. It is because the company has already had all the PC compatible micro-computers, which are the major parts of the system. These computers can be connected together to form a Local Area Network (LAN).

There are a number of characteristics which distinguish LANs from other possibilities like Multi-User Systems such as high flexibility, low cost, high speed, simplicity and reliability.

Flexibility

The size of a LAN is very flexible and it only depends on the needs of the company. A LAN can be as small as only two nodes and can be expanded according to further needs. In addition, the performance of the LAN will not be degraded as the network expands. It is because as it expands, the processing power will also be increased accordingly. It is important as the company may want to implement the system in phase.

Cost

LANs involve low-cost microprocessor systems like IBM PC compatible micro-computers and add-on network boards. Since the company has already had the computers, the proposed LAN should be economical.

Excluding the cost for the computers, the hardware cost of a node currently ranges from around HK$1500 to $3000 per node, which includes the add-on network board and the wiring cost. Therefore, it is cost justifiable in view of the benefits which the company can obtain.

Speed

The most common data rate of currently available LANs is 10 Mbps (10 million bits per second). This high data transfer rate makes the real-time retrieval of information possible.

Simplicity

A LAN is easy to install. Usually most experience people can snap the network board into place in a PC compatible micro-computer within ten minutes, thus installation time is minimal.

Another important factor is the ease of use of LANs. Since the network is based on the ordinary PC, the users do not need to learn a new machine. It is very important because the target users of the Information System are the managers who may feel that they are too busy getting work done to learn a new tool.

Reliability

Because the distances covered by the LAN are small (usually 1500 feet is acceptable), the error rate is very low. Research on this area has shown that the average error rate is 1 in 10^{11} bits of data transferred[8]. Therefore the information is very reliable.

The Central Database

The Central Database is the heart of the system. It contains master files of all the manufacturing activities and these files are updated in real time. The database, which is divided into on-line and off-line portions, is stored in a central file server. Typical file size of the central on-line database is estimated to be

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8. Hopper, Temple and Williamson, "Local Area Network Design", International Computer Science Series, 1986, pp. 10.

about 10 Mbytes per week. Any data beyond a month would be put off-line for batch processing e.g. reports generation.

System Input Devices

The data-driven OLRTIS involves mundane activities of data collection and entry. However, if the numbers are misleading when they go into the system, they will be misleading when they come out. In order to ensure fast, accurate and reliable data collection, the selection of the right data-collection method is essential so that the time and money invested are not wasted. It is suggested that bar code scanning should be used for most data collection activities.

According to Cutter Information Corporation[9], a keyboard entry operator has an average error rate of one in fifty (1:50) compared to that of a bar code which is typically one in three million (1:3,000,000), which is a 60,000 percent improvement in accuracy. In addition to the exceptional accuracy, bar code data entry is typically three to five times faster than that of conventional keyboard data entry. Therefore cost and time savings would become very substantial.

Basically the use of bar code scanning as input devices can be used in most of the manufacturing activities in electronics manufacturing firm. It includes raw materials management, work-in-process inventory management,

9. C.J. Chang, "The Power Of Bar-Coding", Asia Computer Weekly Publication, Nov 14, 1989, pp.34

material movement and even packaging and shipping. Recent studies by the US Department of Defense[10] have shown that annual tangible savings attributed to the use of bar code scanning in its operations amounted to US$113.9 million, which excludes all the intangible benefits like greater accuracy, improvement in production flow and reduced inventory investment levels.

A typical configuration of bar code scanning for the company consists of a PC AT computer connected to a scanner network controller which can drive up to thirty-two bar code scanners[11]. The number of bar code scanners required in each manufacturing process is listed in the Table 2.

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10. C.J. Chang, "The Power Of Bar-Coding", Asia Computer Weekly Publication, Nov 14, 1989, pp.34

11. This scanner network controller is readily available in the market and uses RS-485 multidrop as the protocol.

TABLE 2

NUMBER OF BAR CODE SCANNERS REQUIRED IN THE MANUFACTURING PROCESS

Manufacturing Process	No. of Scanners
a. Incoming Inspection	3
b. Preform	6
c. Auto-insertion	4
d. Stuffing	18
e. Wave-soldering	2
f. Touch-up	13
g. Final assembly	10
h. Testing	20
i. Final inspection	4

The number of bar code scanners allocated to a department is roughly proportional to the number of workers in the department.

Terminals for Inquiry

Twelve general purpose PC/AT computers, which act as inquiry terminals by managers and supervisors, are required. Since the company has already installed these computers, the only expense will be the cost for the LAN hardware for each computer.

The Operating System

A Network Operating System (NOS) is required for the implementation of the Local Area Network described above. There are a lot of different NOS available in the market, but the most powerful and reliable NOS that meets the needs of the system is the Novell Advanced Netware Operating System by Novell Inc. With a compatible price, it provides all the network functions like sharing of devices and files, file locking, security and peripheral resources sharing.

Software

The suggested OLRTIS requires six major software modules. These are:

Data Collection

This is the first software module which is responsible for validating all the received data from the Data Collection Devices including the Bar Code Scanners and Keyboard Entry. In addition, the module also consolidates the data and sends the data to the Central Database for master file updating.

Defect Reports

It is responsible for reporting historical information on defects of raw materials including the components and printed circuit boards. The information is updated in a real-time manner and can be retrieved at any time. Based on the information, all the vendors that do not meet the specifications can be identified and disqualified. All the corrective actions can then be taken by the management immediately.

Statistic Process Control (SPC)

This software module is responsible for keeping track of the latest information on the production process in order to alert management instantly in case any process is out of control. The module includes the computation of the control limits, calculation of standard deviations and capability ratios, and calculation of the number of standard deviations from the average to the specification limits. It also statistically provides yield prediction based on the historical data.

Work-in-process (WIP) Tracking

This software module keeps track of work-in-process inventory in a real-time manner. It is responsible for monitoring the WIP quantity of each manufacturing process and it also alerts the management instantly when the WIP inventory is beyond the control limits. This module can also identify the bottleneck process. The information can be retrieved by management at any time to identify areas for improvement.

Production Management

This software module is responsible for updating and keeping track of production information like machine down-time, operators' idle-time, yields of each manufacturing process, time spent on each operation, material usage and number of scrapped products. Based on the information, management can have a better understanding of what is going on in the production line. In case when processes are out-of-control, corrective actions can be taken immediately to put the operation back in control.

Information Retrieval

The results of the analysis performed by the above modules should be readily retrieved by the management and presented to them in an easy-to-understand form. This is done by this software module. The information generated by the above modules is processed and displayed via the terminals for management inquiry. Moreover, this module also provides hard copies of these information for back-up purpose in case of system breakdown.

The block diagram in Figure 4 summarizes the flow of information of the OLRTIS.

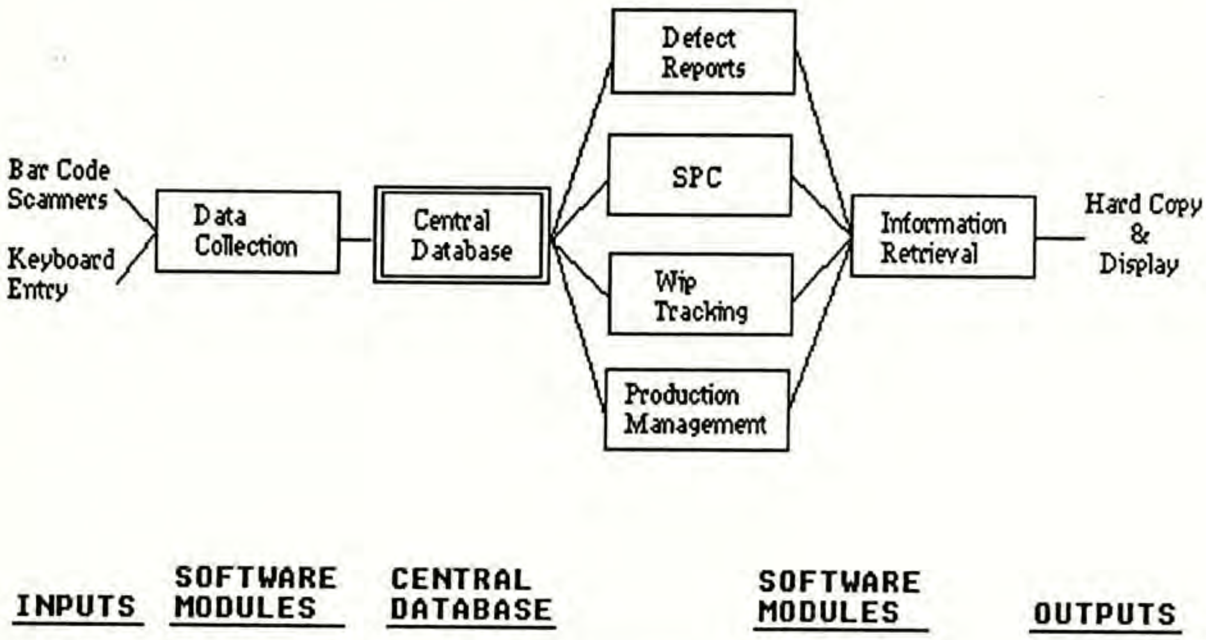


Fig. 4 Block Diagram of OLRTIS

Data Backup and Reconstruction

In spite of sound security measures, abnormal events such as hardware malfunctions, natural disaster and operator mistakes may cause important data to be lost. Therefore, it is necessary to maintain backup i.e. duplicate copies of data files, data bases and programs in order to promptly reconstruct the data. These backup copies should reflect all changes made in software and documentation, as well as the up-to-date status of the files. One set of backup copies should be stored at a location that is physically removed from the computer facilities.

The most important element of the OLRTIS is the Central Database as it contains all the real-time shop-floor production data. The backup procedure for the Central Database is made up of two major steps. Firstly, the contents of the data base are duplicated (dumped) periodically onto a backup medium. The data base may be dumped at the end of each workday onto magnetic tape. Secondly, an activity log is maintained on a continuous basis. The activity log contains images ("snapshots") of the items in the data base that are changed by each transaction, plus the time of the transaction, the files affected, and other useful data. For each item changed, the log shows both the value before the change and the value after the change.

These two backups, namely, the dump and the activity log enable the data base to be reconstructed after serious system failure. The reconstruction of the Central Database can follow a process known as rollback and recovery. The process begins with the most recent backup file being loaded onto a new magnetic disk (i.e., the rollback phase). The recovery phase then consists of recording the after-change values for each transaction from the activity log until the data base is brought back to the point at which the interruption occurred.

Implementation of the Proposed OLRTIS

The software modules of the OLRTIS will be implemented by DataBase Management System (DBMS) programming languages like Dbase IV and Clipper. These programming languages provide ease of development and maintenance of the software modules as well as the flexibility for future expansion. In addition, the C programming language is also required and is responsible for the interface between the Input/Output (I/O) devices like the bar code scanners and the Central Database. Due to the complexity of the system, the software development time frame is estimated to be about three man-years.

Since the development of the new system involves in-depth understanding of the nature of the business like the assembly process and the interaction between the departments, personnel from all the departments would be involved. Therefore it is suggested that the development of the system should follow the in-house development approach by contract programmers rather than seeking outside software development companies to development the software modules.

For the hardware, it is suggested that the installation of the OLRTIS should be in line with the software development so that the software modules can be tested in a real factory environment when they are under development.

Pilot run of the system is scheduled to last about three months to allow time for complete system test, and also for the staff to get custom to the new system. During the pilot run period, the new OLRTIS would be phased in gradually and finally would take over the job of the old manual information system.

The new system will be maintained by a full-time programmer. He/She is responsible for both hardware and software maintenance and for the future expansion of the system.

Cost / Benefits Analysis

Economic feasibility is a key concern when evaluating proposed OLRTIS. The resources needed in this new OLRTIS involve expenditures, as do all other resources needed by a firm. Thus, their acquisition must be justified on economic grounds. Since such resources normally have expected lives of longer than a year, capital budgeting method such as Net Present Value Model should be employed in the justification process.

Costs

The costs of the new OLRTIS can be broken down into one-time and recurring costs.

One-Time Costs

The one-time costs include hardware, software and other one-time expenditures and are shown in Table 3.

TABLE 3

ONE-TIME COSTS OF THE OLRTIS

Hardware[12]	Qty	Unit Costs	Total
Central File Server	1	US$8,000.00	US$8,000.00
Scanner Controller	3	2,500.00	7,500.00
Development Tools	1	2,700.00	2,700.00
Local Area Network	18	300.00	5,400.00
Scanner Network	80	120.00	9,600.00
Total:			US$33,200.00

Software	Total/US$
Dbase IV Package	400.00
Novell Advanced Netware	2,000.00
Programming (Three Man-Year)	55,400.00
Total:	US$57,800.00

12. Please see Appendix 3 for details of hardware configuration

Recurring Costs

The major object classes for recurring costs include labor costs, supplies costs, hardware or equipment costs, and overhead costs. The recurring costs for the OLRTIS is shown in Table 4.

TABLE 4

RECURRING COSTS OF THE OLRTIS

Items	Costs Per Year
Hardware Maintenance (First Year Free)	US$2,460.00
Software Maintenance (One Programmer)	18,060.00
Supplies	800.00
Total:	US$21,324.00

Other Costs

There are other intangible cost items which cannot be expressed easily in dollar value. For example, the valuable time of the top management spent in learning the new system, and also the time needed by the staff to adapt to the new system.

Benefits

The new OLRTIS can provide benefits by streamlining operations, reducing inventory level, and improving the quality of management planning and control. In terms of measurability, the benefits can be classified as tangible benefits or intangible benefits.

Tangible Benefits

Tangible benefits include all the benefits which can be measured in dollar terms.

Increase of Productivity

With the OLRTIS, time consuming paper work will be replaced by on-line data entry. The labor cost can be reduced by ten percent through the time-study conducted by the Engineering Department in December of 1989.

Reduction of Staffs

Two data entry operators which cost US$14,800 per year can be eliminated.

Reduction in Stock Levels

Optimum inventory levels can save much interest on material costs. Currently, the stock turnover ration is about 3.8, which is about three months turn. With the new OLRTIS installed, the stock carrying can be reduced to two and a half months with a turnover ratio up to 4.4.

Intangible Benefits

Intangible benefits are those benefits which cannot be easily measured and expressed in dollar terms.

Reduced Input and Processing Errors

As bar codes are used to capture data, the input error rate can be reduced and the needs of inventories purging will be minimized.

Smoother Operations with Less Fluctuations and Stoppages

Problems happened in factory-floor such as machine failure, materials shortages are detected in real time, and so the problems can be tackled and solved immediately and production losses are minimized.

Improved Customer Service

With the better and faster response of the OLRTIS, managers are able to respond quickly to changing environments and provide higher level of customer service with respect to deliveries and answers to inquiries. These will improve the company's ability to attract and satisfy customers.

Quality Improvement

As any major manufacturing fault can be easily detected and identified, and corrective actions can be introduced immediately, better quality level of products is achieved.

Better Scheduling

As problems can be detected at the very early stage, labor time will not be spent on waiting for the problem fixings or reworking. Therefore, production cost is reduced due to the more efficient scheduling and utilization of labors.

Better Use of Employees

Currently much of the time of department managers is spent on collating information, monitoring staff productivity and reporting the results upward to top management for review. However, OLRTIS can substantially reduces the time needed for these activities. As a result, more people can be supervised by one person and fewer levels of management are required, thus the operating costs will be decreased. Furthermore, top management can find it easier to adapt the company to new challenges.

Net Present Value Criterion

Table 5 shows the computations for the net present value model in cash basis. The following assumptions are made:

- the effects of taxes are ignored due to its small impact
- net sales, material costs, direct labor costs and stock costs are assumed to have 20 percent increment from year 1990
- with the implementation, the stock turnover will be 4.4 instead of the current 3.8
- the general inflation rate is ten percent
- material costs take up 73 percent of net sales
- direct labor costs take up 11 percent of net sales
- the expected rate of return is 12 percent per year
- the stock carrying costs 12 percent interest rate annually
- the saving in labor costs is ten percent
- the life of OLRTIS is five years

From the calculation, the net present value (cash basis) for the OLRTIS project is found to be US$20,646 which is justified for the investment.

TABLE 5

NET PRESENT VALUE ANALYSIS OF THE OLRTIS

Five Years Forecast On Cost of Sales

(in thousands of US$)	Year Ended December 31 1990	1991	1992	1993	1994	1995
Net Sales	$200,000	$240,000	$288,000	$345,600	$414,720	$497,664
Costs of Sales:						
Material Costs	$146,000	$175,200	$210,240	$252,288	$302,746	$363,295
Direct Labor	$22,000	$26,400	$31,680	$38,016	$45,619	$54,743
Stock Carrying Costs	$5,449	$6,539	$7,847	$9,416	$11,299	$13,559
Stock (Raw Material + W-I-P)	$45,408	$54,490	$65,388	$78,465	$94,158	$112,990
Stock Turnover	4.40	4.40	4.40	4.40	4.40	4.40

Net Present Value Analysis

(in thousands of US$)	Year Ended December 31 1990	1991	1992	1993	1994	1995
Costs Saving:						
Productivity Increment (10.1%)		$2,666	$3,200	$3,840	$4,608	$5,529
Staffs Reduction		$15	$17	$18	$20	$22
Stock Level Reduction		$1,369	$1,643	$1,972	$2,366	$2,839
Total Costs Saving	$0	$4,050	$4,859	$5,830	$6,994	$8,390
Costs:						
Hardware One-Time Costs	$33					
Software One-Time Costs	$58					
Hardware & Software Maintenance	$18	$21	$23	$25	$28	$31
Total Costs	$109	$21	$23	$25	$28	$31
Net Saving/Losses:	($109)	$4,029	$4,836	$5,804	$6,966	$8,359

NPV: $20,646

CHAPTER IV

PRACTICAL CONSIDERATION

Although the suggested On-Line Real-Time Information System has many remarkable features, there are evidence of difficulties and drawbacks. Some important issues are identified below.

Top Management Attitude

One of the greatest difficulty is the lack of computer literacy of the top management. Even thought they have heard about the benefits of computerization in improving productivity and saving money, they are rather reluctant to invest money to install the computerized information system as the major benefits of factory-floor computerization are all intangible while all the expenditure is tangible.

Training of Staff and Workers

It has been mentioned that the suggested Information System brings production benefits to the company. However, the best information system in the world is only as good as the people who apply it. In other words, all that information provided by the system could be useless if the people closest to the process, the factory-floor workers, do not know what to do with it. Therefore one of the major tasks of the management will be the training and development of a workforce capable of getting the most productivity and quality out of the OLRTIS system.

Acceptance/Resistance of the New System

It is well believed that successful implementation of new system is ten percent mechanics (technical), 30 percent education (training) and 60 percent acceptance (people). Therefore, for the OLRTIS to be successfully implemented, it is important to make sure that the employee accepts and actually uses the system. Generally speaking, employee rejects new system because of uncertainties about the impending changes in the new information system. They fear that the changes will disturb their familiar and comfortable work patterns, break up their work and social groups and may cause the loss of status and even job security.

They will express their forces of resistance aggressively or evasively. Examples of actions of resistance include:

- entering incorrect data into the new system
- blaming the new system for all errors
- bypassing the controls and processing capabilities of the new system e.g. managers may obtain information from informal sources rather than from the system

In order to guarantee the smooth implementation of the OLRTIS, all managers and employees must be fully informed. Reasons for the implementation must be provided instead of just saying what and how the changes are to be made. Newsletters, meetings, seminar, and so forth can be conducted to inform and educate all the affected employees. Emphasis should be put on how the OLRTIS can provide benefits to them and arguments should be presented in terms of the employees' interests. Personnel policies should be announced guaranteeing that displaced employees will be reassign to new jobs and training will be provided.

Moreover, active participation of managers and employees in the implementation of the system should be ensured. Managers should be asked to express their support and employees can be asked to make suggestions and provided data for use in system testing. It is best for the system to be aligned with powerful people in the company such as the president and also operating/line managers.

Finally, assistants who are knowledgeable concerning the use of computer system should be assigned to high-level management to help them to familiarize with the new system in the early stage of implementation.

"Garbage In, Garbage Out"

Although the new system can offer management the factory-floor information, the old rule of "garbage in, garbage out" may still apply. Therefore it is very important to reduce on-line information to only what is necessary for any individual of the management team to make a decision.

Impact of the New System on Management Organisation

The impact of the new system on the roles of management, especially on the middle management, is significant. As mentioned in the acceptability study in Chapter II, much of the time of middle managers is spent operating in a relay role to report to top management the production status of the company. However, the new system can reduce the time needed for these activities considerably. In addition, the system also allows factory-floor information to become more accessible to the top management directly. Therefore the role of middle management will be changed from a relay role to a more problem-solving role instead. This may become a problem since most of the middle management, although technically skilled, may not be capable and experienced in dealing with problem-solving. Therefore re-training and educating of middle management are necessary.

Human Resources

Due to the complexity of the system, the OLRTIS requires an innovative and highly productive team for system development and maintenance. Technical expertise are the most important factor and thus essential for the success of the system. However, with the brain-drain problem that Hong Kong is facing today, the acquisition of the required personnel might represent a challenge that the company must face.

CHAPTER V

CONCLUSION

Today manufacturing competitiveness in Hong Kong is intensifying. Hong Kong manufacturing firms have to adjust themselves to the tougher foreign competition and the growing problems in the territory like brain drain and the rise in labor costs.

This paper has suggested an efficient and cost-justifying way for the purpose: the On-Line Real-Time Information System for electronics manufacturing industry. It is an economical on-line system which delivers the factory-floor information to management in all levels in a real-time manner. With the new system, the management of the company can identify problem areas, monitor results and initiate appropriate actions promptly.

Although the suggested system is neither a decision support system nor a complete CIM system, it is believed that the system will increase the productivity and competitive strengths of Hong Kong electronics manufacturing, and eventually to the overall manufacturing sector.

Since seventies Hong Kong has been shifting from manufacturing economy to service economy. Some people even claim that manufacturing in Hong Kong is out of date and passe. They believe that service economy alone can bring Hong Kong to the best strategic position against the rest of the Four Dragons of Asia (South Korea, Singapore and Taiwan). However, manufacturing is the only way to create real wealth, and with the open-door policy that the mainland China is undertaking, it is evident that manufacturing in Hong Kong is vital and the computerization of production and control system is the only way to maintain the vitality of the Hong Kong manufacturing industry in the future.

APPENDIX 1

THE MAILING QUESTIONNAIRE AND THE COVERING LETTER

Dear Sir/Madam,

Survey of factory-floor computerization of Electronics Manufacturing Companies in Hong Kong.

We are making an investigation into the extent of factory-floor computerization of Electronics Manufacturing Companies in Hong Kong, which we believe that it is crucial for the future growth of the industry.

We earnestly invite you to be one of the 100 electronics manufacturers which we have carefully chosen for the survey purpose. This study is used for academic research only and all the companies will remain anonymous and all the information will be treated in strict confidence.

It would be greatly appreciated if you could reply to as many as you feel free to answer and return the questionnaire in the enclosed stamped envelope before the end of February, 1990.

You, too, will undoubtedly be interested in the results of this survey. To those who assist us, please attach your business card along with the questionnaire and we will send a copy of our findings.

Thank you very much for your sincere cooperation.

Very truly yours,

Brian Leung & Timmy Ng
2nd yr. MBA Students
The Chinese University of Hong Kong

1. Is your Company a manufacturing firm?

   a. Yes,
   b. No

   (if "No", please stop here and return the questionnaire)

2. How many employees are there in your company?

   a. less than 20
   b. 20 - 50
   c. 50 - 100
   d. 100 - 200
   e. 200 - 500
   f. 500 - 1000
   g. more than 1000

3. Does your Company use computers for Data Processing?

   a. Yes
   b. No

   if "No", why?

   a. high start-up costs,
   b. hard to tailor the system for specific needs,
   c. low in investment return,
   d. lack of skilled computer personnel,
   e. cannot fit into the existing organizational structure,
   f. do not know what the computer can do.
   g. others

   ____

   ____

   ***** please jump to question 6. *****

4. How long is the Data Processing history of your company with computers?

   a. less than 1 year
   b. 1 - 2 years
   c. 2 - 3 years
   d. 3 - 4 years
   e. 4 - 5 years
   f. 5 - 10 years
   g. more than 10 years

5. What are the kinds of computers used in the Company?

   a. Minicomputer (please specify) ________________
   b. IBM PC or compatible
      How many? _____
   c. others (please specify) ____________________

6. What are the main applications of the computers?

   a. Word Processing
   b. Accounting
   c. Production planning:-
      i. Master Scheduling,
      ii. Material Requirement Planning,
      iii. Capacity Requirement Planning
      iv. Factory-floor Scheduling,
      v. Vendor Scheduling,
   d. Production Control:-
      i. Inventory Control,
      ii. WIP (Work-In-Progress) Control,
      iii. Cost Control,
      iv. Sales Control,
   e. Manufacturing Database (eg., Bill of Material)
   f. Sales Analysis
   g. Forecasting
   h. CAD/CAM
   i. others (please specify)

   ____
   ____
   ____

7. How is the factory-floor data (eg., yield rate, bond piles & WIP inventory) being collected for management?

   a. Collected by clerks or supervisors in each department independently. Each department submits its own reports to the management.
   b. Collected by a team for all the departments. Data collected from all departments is consolidated and an overall report is prepared for management.
   c. No formal report is prepared.
   d. other (please specify)

   ____
   ____
   ____

8. How does the company prepare production status reports for management?

   a. data manually entered to the computers by data-entry clerks and the computers translate these raw statistics data to management reports,
   b. data entered to the computers by mean of some electronic devices, eg., barcode readers, and the computers do the reports,
   c. reports are prepared without the use of computers,
   d. no formal report is prepared.
   e. other (please specify)

   ____
   ____
   ____

9. How often are the production status reports generated for management?

   a. reports generated in a real-time manner,
   b. at the end of each day,
   c. in the morning of the next day,
   d. once a week,
   e. no formal report is prepared,
   f. other (please specify) ____________________

10. Do you find that sometimes the production capacity of your company is reduced due to the inefficiency of the existing production control system?

    a. yes
    b. no

    if yes, what are the reasons contribute most to the inefficiency of the production control system?
    (1: most, 8: least)

    - slow response to ECO ____
    - slow response to material defects ____
    - machine downtime ____
    - material shortage ____
    - high failure rate in Testing ____
    - large bone-pile due to false rejects ____
    - slow response to machine problems ____
    - WIP inventory too high ____
    - other ________________ ____

11. Please estimate the percentage of the manufacturing cost of your company due to the loss caused by the above reasons:

    a. less than 2%
    b. 2% - 5%
    c. 5% - 10%
    d. 10% - 15%
    e. 15% - 20%
    f. more than 20%

12. What is the monthly production volume of your company in terms of money?

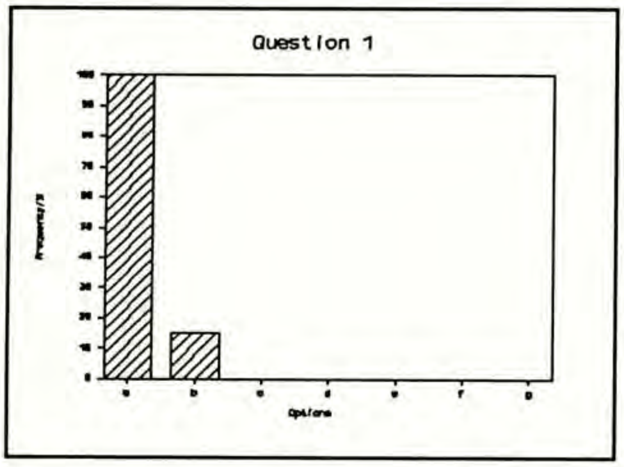
    ____

13. Do you think that a on-line real-time information system for production control will be beneficial to your company?

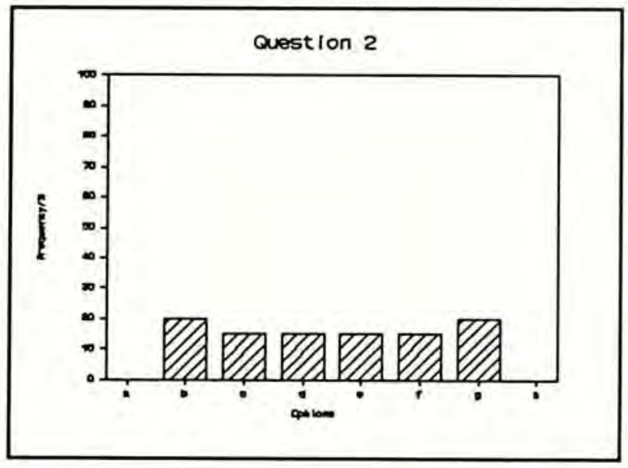
    a. yes
    b. no

APPENDIX 2

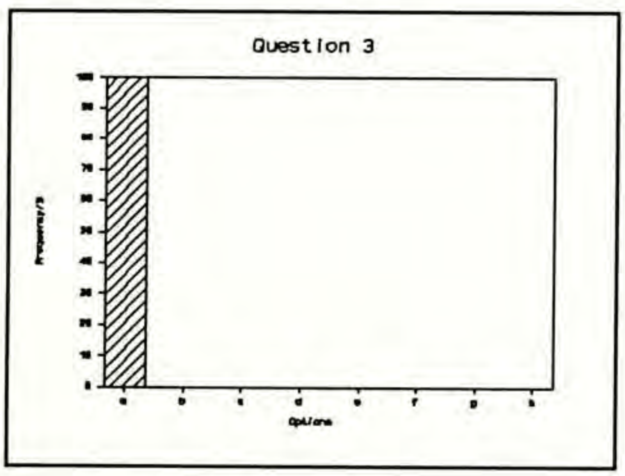
ONE WAY TABULATION ANALYSIS



Question 1



Question 2



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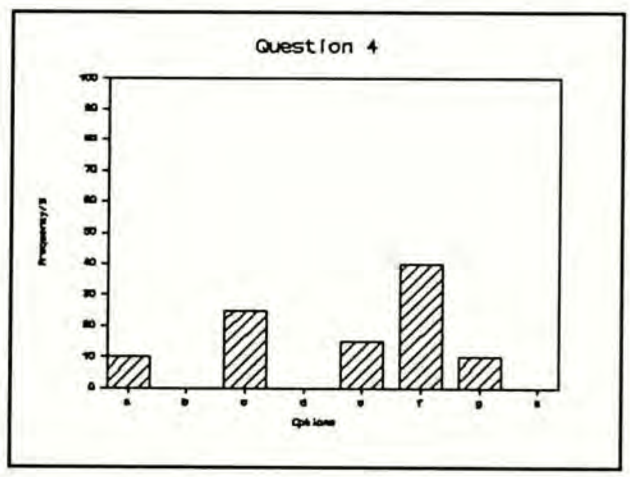

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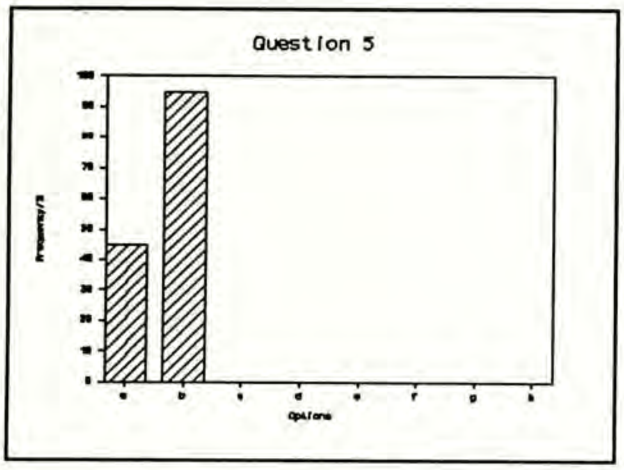

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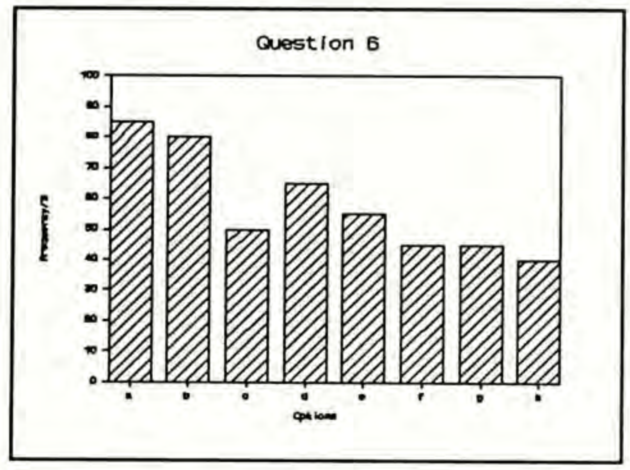
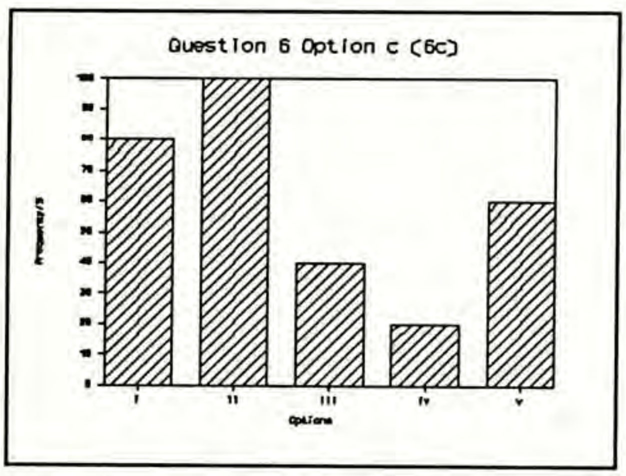
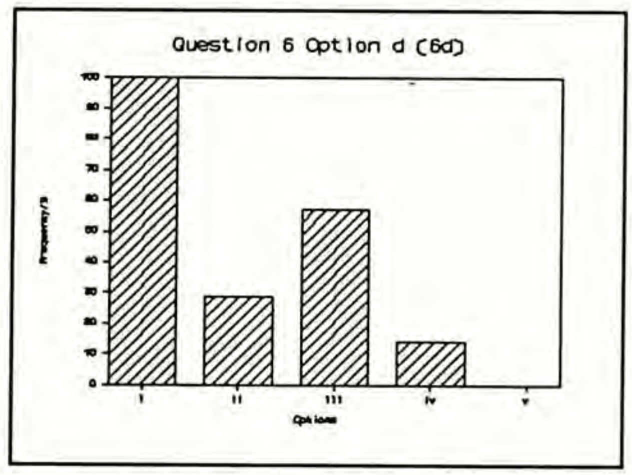


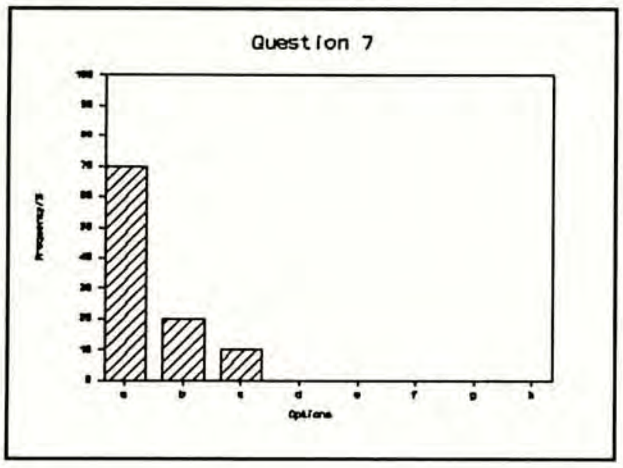
Question 6



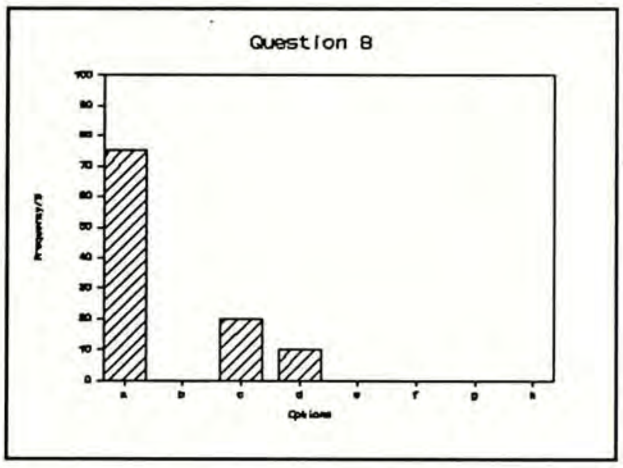
Question 6c



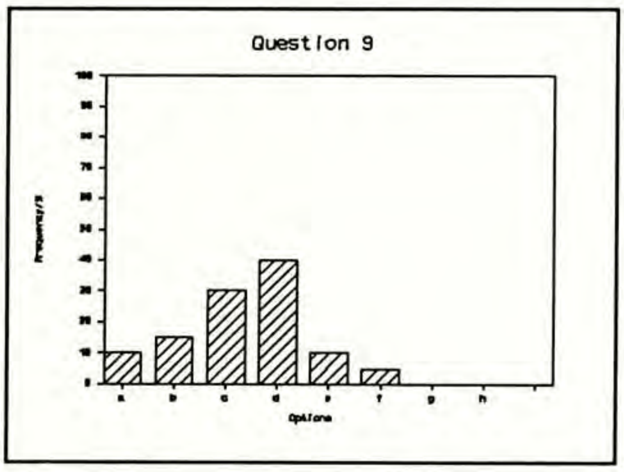
Question 6d



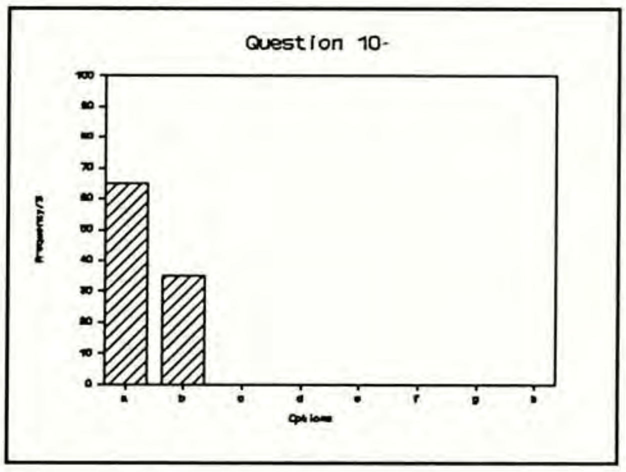
Question 7



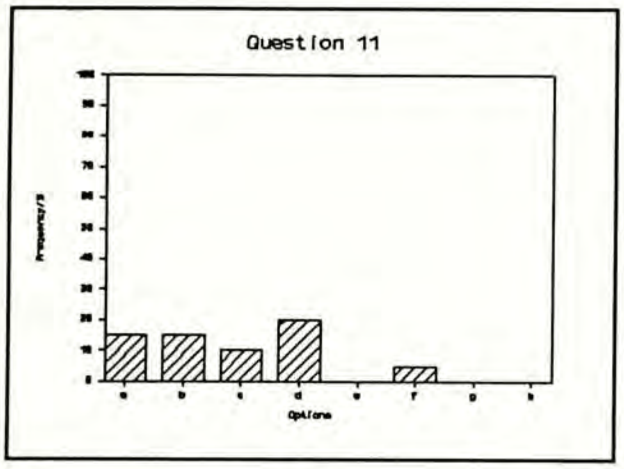
Question 8



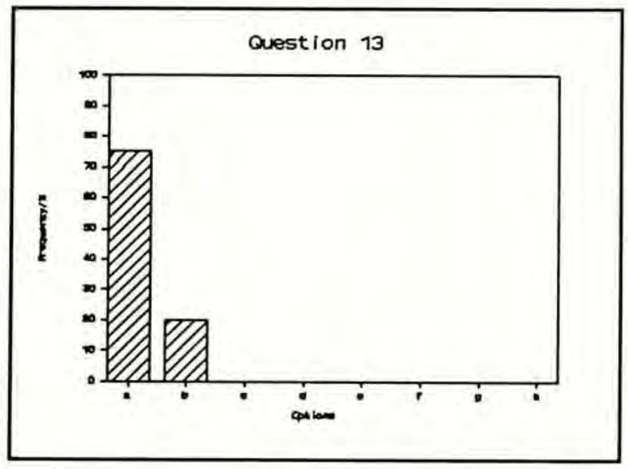
Question 9



Question 10



Question 11



Question 13

APPENDIX 3

DETAILS OF HARDWARE CONFIGURATION OF OLRTIS

Equipment	Description
Central File Server	PC/AT with Intel 80486 microprocessor and 33MHz clock speed, 16 Mbytes on-board RAM and 600 Mbytes fixed disk drive
Scanner Controller	PC/AT with Intel 80386 microprocessor and 25MHz clock speed, 2 Mbytes on-board RAM and 80 Mbytes fixed disk drive
Development Tool	PC/AT with Intel 80386 microprocessor and 25MHz clock speed, 2 Mbytes on-board RAM and 40 Mbytes fixed disk drive
Local Area Network	Eighteen network interface cards with 16-bits bus and six hundred meters of coaxial cables are required.

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